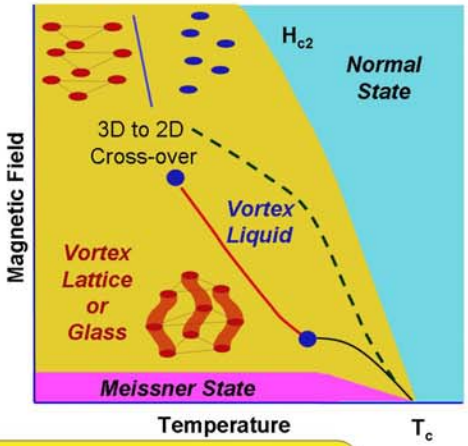
Thermodynamics & Pinning of the Vortex Liquid State

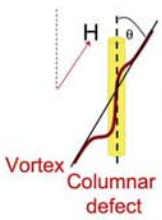
W. -K. Kwok[a], U. Welp[a], R. Xie[a,b] L.M. Paulius[c]
[a] Materials Science Division, Argonne National Laboratory
[b] Department of Physics, University of Notre Dame,
[c] Department of Physics, Western Michigan University

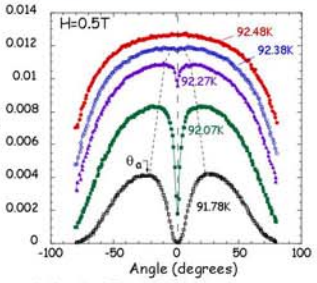
The Vortex liquid is ubiquitous to all high Tc superconductors and provides a new platform to investigate new phases and phase transitions. It also constitutes a barrier for high critical currents at high temperatures and magnetic fields.

- ***Vortex line tension transition in the liquid state: upper limit to pinning by correlated disorder?***
- ***Exploration of novel phase transformations:***
  - ***Evolution of 1st order transition to higher order with increasing disorder.***
  - ***Transformation from 3D to 2D melting at high magnetic fields***
- ***Probe vortex viscosity and single vortex pinning in the liquid state***



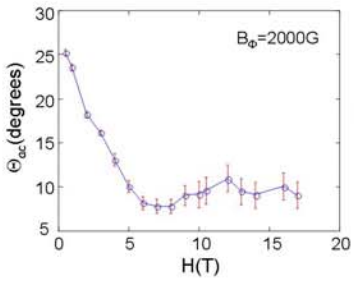
Vortex Line Tension Transition in the Liquid State: upper limit to pinning by correlated disorder?





Columnar defects: B_Φ=2000 Oe

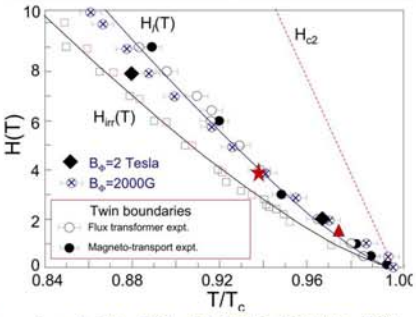
The vortex line tension is probed by anisotropic pinning induced by columnar defects created by heavy ion irradiation.



Saturation of the accommodation (pinning) angle θ_{ac} at high fields

Comparison with Twin boundaries & Defect densities

Columnar defects vs. Twin boundaries

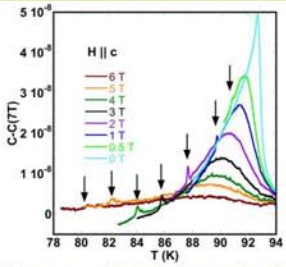


★ splayed ±10., PRL. 79, 2358, 1997 (B_Φ=3T)

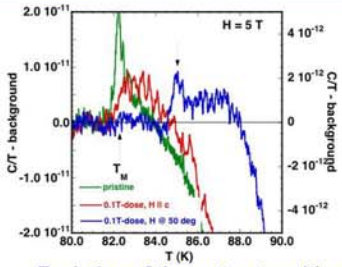
▲ columnar defects, PRL. 77, 981 1996 (B_Φ=2T)

Future: Exploration of Novel Vortex Phase Transformations

Differential nano-calorimeter based on Si_3N_4-mambranes



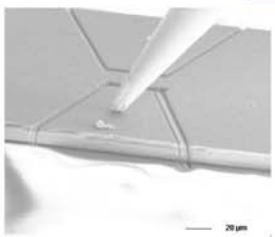
Heat capacity (relative to the 7-T data) of a twin-free, pristine YBCO crystal. The arrows indicate the evolution of the vortex transition.

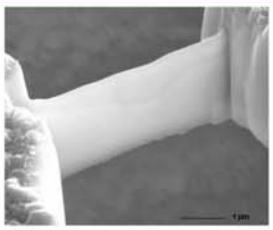


Evolution of the vortex transition in 5 T upon heavy ion irradiation and field orientation.

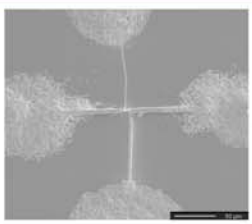
- thermodynamic determination of Bose glass transition
- evolution from 1st order to continuous transition with disorder

Future: YBCO Crystal Bridges: critical current & pinning of the vortex liquid state

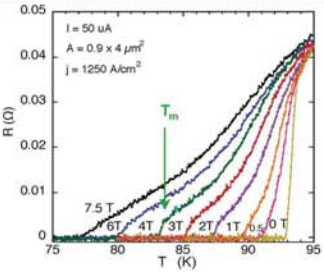




FIB of untwinned YBCO single crystal micro-bridge



4-probe contact



1st order vortex melting transition in micro-bridge

Exploration of single defect pinning and dynamics of vortex confinement

W.-K. Kwok et al., Physica C (2006) (in press)

ARGONNE NATIONAL LABORATORY

This work was supported by the U.S. Department of Energy, Basic Energy Sciences, under contract W-31-109-ENG-38.

THE UNIVERSITY OF CHICAGO

Office of Science U.S. DEPARTMENT OF ENERGY